DISTRIBUTION OF SETÆ IN THE EARTHWORM, *PHERETIMA BENGUETENSIS* BEDDARD [1]

P. B. SIVICKIS

(From the Zoölogical Laboratories, University of the Philippines, Manila and Lietuvos Universitetas, Kaunas, Lithuania.)

The oligochæt genus, *Pheretima,* which occurs abundantly in the Philippines and other oriental countries, is characterized by the presence of a large number of setæ on each segment except the most anterior. Taxonomists have regarded the distribution and number of setæ as specific characteristics, but apparently have observed that the number varies on different segments, since they usually specify the segment for which the number of setæ is given (Michaelsen, 1900; Stephenson, 1923). No data have been found, however, concerning variation in number of setæ on a particular segment. Counts of setæ made by the writer show a considerable range of variation, both in the number of setæ on corresponding segments of different individuals and on different segments of the same individual. Moreover, the numbers of setæ on different segments of the same individual vary along the axis in a way which suggests a relation to the longitudinal physiological gradients. Data are given below concerning these variations.

Material and Methods

Pheretima benguetensis Beddard, the species on which the counts were made, is common in the Philippines. During the greater part of the rainy season the worms are found in large numbers near or on the surface of the ground. By the end of the rainy reason they become heavily parasitized by gregarines and later disappear almost completely, but whether the disappearance is due to death or to movement away from the surface of the ground is not known.

Counts of setæ were made on one hundred animals. Fifty of these were collected on the campus of the University of the Philippines and fifty from the town of Pasig near Manila. The latter were somewhat larger than the former, but their general specific characteristics indicated that both lots belonged to the same species.

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The counts were made on animals preserved in formalin. For counting they were opened along the mid-dorsal line, the internal organs were removed, and the body wall was cut into pieces of a size convenient for microscopic examination between two slides. Counts of such pieces were either made at once or the two slides with the piece between them were tied together and placed in a hot one per cent solution of KOH for five hours or more, until they became transparent, but were removed before maceration had proceeded so far that the setæ were freed from the tissue. A section along the dorsal midline is more satisfactory for such preparations than a section elsewhere because the dorsal wall is thicker than in other regions, and since the KOH attacks the edges of the preparation first, the thicker dorsal wall is not destroyed before the other parts have become sufficiently transparent. After maceration the pieces were mounted in glycerol and all the setæ on the segments selected were counted under a low power of the compound microscope with the aid of a mechanical stage. Particular care was taken to make certain that all setæ on each segment selected were included in the counts. In the region of the clitellum counts are less readily made than elsewhere because the thickening of the body wall in this region makes it difficult to see the setæ.

Since there are no setæ on the first segment, counts were begun with the second, and further counts were made on the fifth, tenth, fifteenth, etc., that is, on every fifth segment up to the sixtieth. In order to minimize possible errors which, however, proved to be less than was feared, in counts on the fifteenth segment, a segment of the clitellum, counts were made on the segment next anterior (13) and the segment next posterior (17) to the clitellum. Counts from the posterior direction began with the last posterior segment and were made on every fifth segment until the sixty-fifth segment from the posterior end was reached. This procedure leaves a short middle region uncounted in some animals with a large number of segments, but since the mean number of segments can readily be extrapolated in this region, the results are not seriously affected.

The method of making counts in two directions from each end of the body is regarded as preferable to that of making counts from anterior to posterior end, because by the latter method the most posterior segment counted is rarely the last segment of the body and represents different levels in different cases.

Distribution and Size of Setæ

Each segment except the most anterior possesses a large number of setæ more or less uniformly distributed about the circumference,

but with occasional gaps and occasional duplications. The setæ are less than a millimeter in length, and taper slightly from the base to a blunt tip.

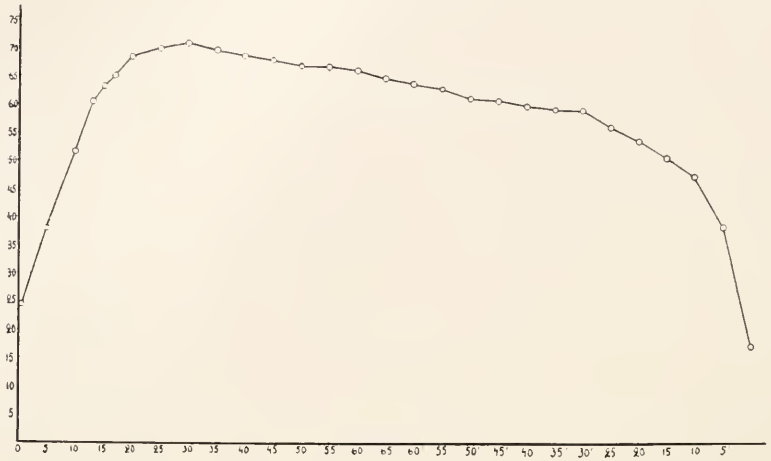

FIG. 1. Graph from the data of Table I showing the variation in numbers of setæ along the main axis of the body in *Pheretima benguetensis*. Ordinates represent the mean numbers of setæ (*M*) on particular segments; abscissæ represent segment numbers. The anterior end is at the left.

Setæ from three regions of the body have been isolated by boiling in KOH pieces of the body wall from the selected regions and have been measured with an ocular micrometer. The data of such measurements are as follows:

On segments	2–5,	length	0.6 mm.;	diameter	0.08 mm.
" "	36–40,	"	0.3 mm.;	"	0.05 mm.
Last ten segments,		"	0.5 mm.;	"	0.03 mm.

These measurements indicate the variation in size of the setæ. The longest setæ are found on the anterior and posterior segments, the shortest in the middle regions. From the anterior end the setæ very gradually decrease in size to the clitellum. For some distance posterior to the clitellum the setæ are only about half the length and little more than half the diameter of those on the anterior segments. Posterior to the middle of the body they begin to increase in size and for the most posterior segments they are almost as long, though less in diameter than those at the anterior end. In general the length of the setæ varies inversely as their number.

TABLE I

Numbers of Setae on Selected Segments of First and Last Ten Individuals of Pheretima Benguetensis out of One Hundred Counted. The last two horizontal lines give the mean values (M) and standard deviations (σ) for corresponding segments of one hundred animals.

Worm Number	Segment Numbers																												Number of Segments
	2	5	10	13	15	17	20	25	30	35	40	45	50	55	60		65′	60′	55′	50′	45′	40′	35′	30′	25′	20′	15′	10′	5′	1′	
1	22	33	52	48	53	54	65	67	69	72	70	74	65	60			55	52	53	51	50	50	53	41	45	40	41	38	30	22	128
2	24	39	49	55	60	65	67	69	71	74	69	66	69	65			54	54	57	55	51	53	53	47	45	48	42	43	35	22	127
3	21	33	46	50	50	58	66	64	65	60	58	58	62	58	53		54	54	56	50	54	47	52	47	48	49	48	40	36	11	133
4	30	43	48	56	60	60	74	70	74	76	76	71	72	69	72		69	67	65	66	70	68	67	65	61	54	53	51	43	17	130
5	34	43	55	65	69	70	75	75	76	75	74	72	70	69	70		74	76	75	69	69	71	70	64	61	64	60	55	46	12	131
6	22	33	45	58	56	58	61	64	62	59	55	58	54	57	61		58	59	55	53	52	55	49	49	46	47	42	44	34	7	134
7	23	33	50	56	58	59	62	66	67	60	55	54	60					59	61	58	58	59	60	58	58	57	50	46	42	15	115
8	20	42	50	68	70	75	75	77	76	75	71	74	73	71	73		68	68	65	64	66	62	60	63	62	60	54	49	44	10	134
9	25	37	46	59	60	61	62	65	66	60	64	68	65	66	60		60	57	58	56	58	57	57	56	51	50	50	47	38	11	134
10	20	40	42	52	54	58	68	66	65	64	66	65	67	64	63		58	60	58	56	55	50	56	59	58	58	52	50	32	12	132
91	27	40	58	67	68	63	81	76	78	77	76	80	76	73	74		72	71	68	65	72	67	66	63	59	57	53	51	40	28	134
92	24	39	48	60	58	61	60	61	63	62	65	72	74	71	69		72	67	69	71	68	63	65	60	57	52	47	40	31	17	136
93	17	35	49	62	66	72	76	81	74	69	68	73	71	69	71		68	70	67	70	69	65	61	61	59	56	48	45	42	22	132
94	21	39	53	58	61	67	65	72	75	72	72	68	65	68	67		67	69	71	70	63	60	63	61	58	54	51	35	32	7	140
95	18	42	46	60	67	69	73	75	67	74	71	66	67	70	69		68	68	65	67	68	62	61	65	59	60	52	47	29	14	128
96	29	38	65	66	70	73	82	79	78	74	76	76	78	80	76		74	69	66	65	63	61	60	59	62	56	47	33	27	12	140
97	24	37	60	62	65	66	72	73	75	72	70	71	74	71	66		65	68	64	66	61	59	57	58	53	56	54	46	41	10	133
98	22	35	54	65	67	77	81	74	76	77	80	71	68	71	71		68	70	68	66	60	63	65	62	55	57	49	37	32	20	138
99	24	34	48	55	57	62	71	70	68	68	66	65	63	61	52		59	62	60	63	61	58	55	52	51	49	46	45	35	9	134
100	27	44	59	63	67	74	77	76	79	75	73	76	72	69	68			67	65	63	58	54	52	47	48	43	46	39	35	16	122
M	24.5	38.0	51.8	60.8	63.4	65.3	68.5	69.9	70.9	69.5	68.7	67.8	66.8	66.8	65.9		64.8	63.7	62.9	61.0	60.8	59.7	59.0	59.0	55.7	53.6	50.8	47.3	38.4	17.4	131.0
σ	3.59	3.02	5.07	5.29	4.62	5.39	6.29	5.68	6.00	5.69	5.56	5.86	5.64	5.17	4.81		5.24	5.38	5.23	5.24	5.49	5.60	4.64	5.18	4.85	5.07	4.98	5.39	6.60	9.68	5.02

Counts of Setæ

The numerical data for the first ten and the last ten animals of the hundred counted are recorded in full in Table I as a sample indicating how the counts run. Animals 1–10 of the table are from those collected on the University campus, animals 91–100 from those collected at Pasig. The first vertical column gives the number of the individual in the series, the following column the number of setæ counted on corresponding segments. The first vertical section of the table gives counts from the anterior end to the sixtieth segment, the second section, counts from the posterior end to the sixty-fifth segment from that end. The last column gives the number of segments in each animal. In the last two horizontal lines of the table are given the mean values (M) and the standard deviation (σ) as calculated by the standard formulæ for corresponding segments of all animals counted, that is, each value of M and σ given is the value for one hundred corresponding segments. The variations of M at the different body levels are plotted in the graph (Fig. 1).

Examination of the data recorded in the table shows that in spite of a considerable variation in the number of setæ per segment of any individual, the general course of the variations in different regions is well expressed by the means. The number of setæ is relatively small on the anterior segments, but increases rapidly to the twentieth segment, beyond this more slowly to the thirtieth segment, where the maximum number of setæ per segment is attained. Posterior to this segment the number of setæ decreases gradually to the posterior end of the body.

Discussion

The very definite course of variation in number of setæ along the body of *Pheretima* suggests that it must be correlated with regional physiological differences of some sort, and since it is gradual and in opposite directions in anterior and posterior regions, the possibility that it may be in some way correlated with the longitudinal physiological gradient in the body is also suggested. Nothing is known concerning the gradients in *Pheretima,* but in most other oligochæts examined a double gradient has been found. Hyman (1916) has found in most of the microdrilous oligochæts a decrease in susceptibility from the anterior end posteriorly to a certain level and an increase from this level to the posterior end. Hyman and Galigher (1921) found a similar double gradient in oxygen consumption in *Lumbriculus* and *Nereis.* Perkins (1929), investigating oxygen consumption, total iodine equivalence, amount of glutathione and total sulphur content in different regions of the body

of an earthworm (unnamed), also finds differentials which vary in two directions. If such a double gradient exists in *Pheretima,* as is probable, the smaller numbers of setæ occur at the higher, and the larger numbers at the lower levels of the respiratory gradient. We know nothing at present concerning the nature of the relations between gradients and setæ, but it may be provisionally suggested that a developing seta sac in the regions of more intense metabolism inhibits the development of other seta sacs over a greater distance than in regions of lower metabolism, consequently at the higher gradient levels fewer setæ develop on the circumference of the segment than at lower levels. Such an inhibiting action of a developing part or organ on other similar organs within a certain distance from it is very generally recognized by both botanists and zoölogists, and in various cases the range of this effect appears to be very definitely associated with the intensity of metabolism in the part concerned. Whether this suggestion of a possible relation between the numbers of setæ on different regions of the body is correct must remain for further investigation to determine.

In addition to the regional variations in numbers of setæ, individual variations in number on corresponding segments appear in the table. The standard deviation σ is lowest in the anterior region of the body. This is particularly evident anterior to the tenth segment. The highest value of σ appears in the posterior region, particularly in the ten posterior segments. Between these extremes σ fluctuates between 4.62 and 6.00. The relatively low σ of the anterior region suggests physiological stability in this region, and this is in accord with the fact that it develops first and represents a dominant or relatively dominant region. It is much less affected by parts posterior to it than they are by it.

With respect to the practise of taxonomists of considering the number of setæ on a particular segment as a specific character, it may be noted that the data presented in the table show a very considerable individual variation in these numbers and a high value of σ. Apparently counts on many individuals would be necessary to make these numbers reliable for species determination. Smaller numbers may, however, be considered as possessing a certain diagnostic value when considered together with other characters.

Some observations on *Pheretima posthuma* (*P. incerta* Beddard) indicate that with certain limitations similar relations exist in that species.

Summary

The numbers of setæ on particular segments of *Pheretima benguetensis* vary in definite directions in different regions of the body. The number is lowest on the most anterior segments, increases posteriorly to a maximum at a level just posterior to the reproductive organs, and then decreases gradually to the posterior end. A relation between this course of variation and the physiological gradients is suggested. The standard deviations for corresponding segments indicate that the number of setæ on a particular segment should be used for determination of species only in connection with other characters.

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